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Adhesive composition

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ADHESIVE COMPOSITION

The present invention relates to a creping adhesive composition, in particular to a creping adhesive composition suitable for application to a creping drum in an apparatus for producing soft, light-weight paper web suitable for making sanitary paper products such as bathroom and facial tissue, paper towels and napkins.

It is conventional practice to produce soft paper web by mechanically or chemically disrupting interfibre bonds in the paper web thereby to reduce the strength of the paper web. Examples of known methods of producing such softened paper web are to crepe paper web from a drying surface with a creping blade; to crepe paper web a second time after the web has been creped from a first drying surface; or to add chemical debonders to the fibrous material which forms the web. However, such conventional methods generally result in the production of paper webs having relatively low strengths for a given improvement in softness.

Compression of the paper web when it is wet encourages the formation of interfibre bonds, and a successful approach to the production of soft paper has been to minimise the formation of these bonds during manufacture of the web by avoiding mechanical compaction of the wet web at any stage thereby producing webs commonly referred to as "never-pressed" webs. In these processes, drying of the web is achieved using through-dryers which direct air through the web, and it has been found that the internal structure of such "never-pressed" webs has an inherent bulk and softness which gains the maximum benefit from a subsequent creping step.

Consumer demands for still softer sanitary paper products have meant that it has become increasingly difficult to produce paper of the required softness from conventional equipment for making soft-paper in which type of equipment the web is pressed to remove water and then creped from the surface of a Yankee dryer. Although better results

have been achieved using the through-dryer technology discussed briefly above, such equipment is very expensive both to install and to operate. There has therefore been a substantial demand for methods of manufacturing soft paper which are capable of utilising conventional Yankee paper machines but which result in a softer product than has hitherto been possible to achieve on such equipment.

In an attempt to reach these desired quality levels, proposals have been made for adding a second creping stage to a conventional single-crepe Yankee paper machine, but generally these have not been successful in producing a light-weight sanitary tissue web having a basis weight in the range of 14 to 34 g/m^2 (8 to 20 $lbs./2880ft^2$) with the required degree of softness. Rather, paper of this weight produced on such machines has not generally exhibited the balance between softness and strength which is required for sanitary paper products.

We have developed a method of making a creped paper web which is comparable in softness and strength to "never-pressed" paper webs but which can be produced using conventional equipment incorporating mechanical de-watering and a Yankee dryer on which the web is dried and then creped.

This method, hereinafter referred to as our dual-creping method, is described and claimed in our co-pending British Patent Application No. 8401492. In that patent application we describe a method of making a soft paper web having a basis weight of from substantially 8 to 20 $lb/2880ft^2$ comprising the following sequence of steps:-

(a) forming a web from a slurry;
(b) applying the web to the surface of a Yankee dryer:
(c) creping the web from the surface of the Yankee dryer at a dryness of substantially between 93 and 97% by means of a first creping doctor;
(d) drawing the web from the creping doctor and treating the web to reduce the elasticity of the web introduced by said first creping step such that the mean square stretch of the web, as defined below, is not more than 9%;

(e) applying the web by means of an overall adhesive to a creping drum; and

(f) creping the web from the creping drum by means of a second creping doctor at a dryness of at least 93%.

The mean square stretch (MSS) of a paper web is defined by the equation:

$$MSS = \sqrt{MDS \times CDS}$$

where MDS is the percentage stretch in the machine direction and CDS is the percentage stretch in the cross-machine direction.

The creped paper web produced by the said method is comparable in softness and strength to "never-pressed" webs. An advantage of our dual-creping method is that the creped paper web can be produced using conventional equipment incorporating mechanical de-watering and a Yankee dryer on which the web is dried and then creped. This advantage results from the use of a dual creping process in which the first creping step is controlled so as to condition the internal and surface structure of the web in such a manner that the creping response is maximised at the second creping stage. Such an arrangement is capable of producing soft paper at lower cost than apparatus using through-dryers to promote drying of the paper.

In order to optimise the performance of the second creping stage, i.e. creping of the web from the creping drum, we have found that it is important that the web is strongly adhered to the creping drum over substantially its whole surface area, so that very high creping forces are employed to detach the web from the creping drum.

Under such conditions extensive disruption of the fibre bonding is achieved within a thin layer of the web which is in contact with the drum resulting in a significant improvement in the softness of that

web surface. The remainder of the web is creped in a very fine pattern.

A problem arises in creping at the higher levels of adhesion attainable by the use of thermoplastic creping adhesives if the adhesive composition does not enable a uniform film of adhesive to be maintained on the creping drum over the extended periods of time required to obtain acceptable machine operating efficiencies. Adhesives which provide the desired levels of adhesion tend to build up in thickness on the creping drum, usually in a non-uniform manner, resulting in variable adhesion and variable product properties. Attempts to control the uniformity of the residual adhesive film by mechanical means as, for example, by frequent changes of doctor blades, are undesirable because of the resulting adverse effect on machine operating efficiencies.

A further problem arises in the use of thermoplastic adhesives in that portions of the adhesive which remain on the web surface after removal from the creping drum tend to cause the web to stick to itself as, for example, when the web is wound into rolls. This sticking of the web, termed "blocking", can interfere with the subsequent unwinding of the web from the roll. The extent of the blocking depends on the nature of the adhesive, the amount of adhesive retained on the web surface, the moisture content of the web, the contact pressure arising in the wound roll and the temperature. Blocking is decreased at lower temperatures. Some cooling of the web occurs naturally from the point of creping to the point of winding of the web into a roll. Some additional cooling of the web is possible at low cost by the forced application of air at ambient temperatures onto the web surfaces. Still further cooling of the web as, for example, might be obtained by the use of refrigeration systems is costly and can be avoided by the use of adhesives which have minimal blocking tendencies at the roll winding temperatures which are either attained normally or are attainable by the blowing of ambient air onto the web.

We have found a creping composition which provides the level of adhesion needed for the development of improved softness and bulk in creped products at desired product strength levels, which also provides uniform polymer adhesive films on the crepe dryer and which permits the web to be wound into rolls at temperatures of up to 50°C without operational difficulties from blocking.

Accordingly, the present invention provides a thermoplastic creping adhesive composition which is in the form of an aqueous polymer dispersion, comprising, as solid adhesive components dispersed in an aqueous medium:

(a) a major proportion of a vinyl acetate homopolymer and/or a vinyl acetate copolymer in which the vinyl acetate units form at least 90% by weight of the polymer, the said homopolymer or copolymer having a molecular weight of from 500,000 to 1,500,000 and a glass transition temperature of from 28 to 36°C., and

(b) a minor proportion of a vinyl acetate homopolymer or copolymer having a molecular weight of from 5,000 to 250,000 and a glass transition temperature of from -50 to 32°C.

The main component (a) in the compositions of the present invention is a high molecular weight homopolymer or copolymer in which vinyl acetate comprises at least 90% by weight of the polymer. Polymers having molecular weights below 500,000 do not develop creping forces high enough to achieve the desired improvement in web properties, whereas polymers having molecular weights above 1,500,000 do not enable satisfactory films to be maintained on the creping drum.

Polymers which are either vinyl acetate homopolymers or copolymers containing at least 90% vinyl acetate will have glass transition temperatures in the range of 28 to 36°C.

We have found that by adding to component (a) as defined above, a low molecular weight component - component (b) as defined above - either as a vinyl acetate homopolymer or as a copolymer of vinyl acetate with other monomers, such as octyl maleate, butyl acrylate or 2-ethyl hexyl

acrylate, the desired adhesive forces can be obtained while also providing for the development and maintenance of a uniform adhesive film. Polymers of this kind will have glass transition temperatures between -50 and 32^{o}C.

The amount of component (b) needed in admixture with component (a) to obtain the desired creping performance has been found to vary with the molecular weight of component (b). For example, we have found that when component (b) is a vinyl acetate homopolymer having a molecular weight of from 100,000 to 250,000, an amount of component (b) of from 20 to 40% by weight, based on the total weight of the solid adhesive components of the adhesive composition is preferred. Similarly, when component (b) is a copolymer of vinyl acetate having a molecular weight of from 5,000 to 75,000 the preferred amount of copolymer for developing the desired adhesive properties is from 4 to 10% by weight, based on the total weight of the solid adhesive components of the adhesive composition.

We have found that the creping adhesive compositions of the present invention permit the winding of the creped webs into rolls without blocking problems when the temperature in the wound roll is below 50^{o}C. Under normal operating conditions, temperatures of 50^{o}C or less are usually present; if not temperatures of 50^{o}C or less can be obtained by the forcing of ambient air onto the web surfaces as the web is transported from the point of creping to the point of roll winding.

In operating our dual creping process, the adhesive compositions of the present invention are applied to the creping cylinder in an amount of 0.12 to 0.3 grams of polymer nonvolatile solids per square metre of cylinder surface contacting the web.

We have found that the creping adhesive compositions of the invention have adhesive properties which are particularly well suited to the conditions of operation of our said dual-creping method, and in particular that the adhesive compositions are well suited for use in a

said dual creping method in which the temperature at the second creping drum is from 110 to 132°C.

The invention will now be illustrated by the following Examples. In the Examples, percentages are by weight unless specified otherwise.

Basis weight (BW) is the weight per unit area of a sample of paper web; i.e., g/m^2.

Bulk is measured using a Federal Bulk Tester which measures the thickness of 24 sample sheets under a load of 36.4 g/cm^2.

The following properties of the paper web: machine direction tensile strength (MDT), machine direction stretch (MDS), cross-direction tensile strength (CDT), and cross-direction stretch (CDS) were measured in accordance with TAPPI Standard T220M-60. The mean square stretch (MSS) has been defined above.

Handfeel (HF) is measured subjectively by a panel of individuals against standard samples having handfeel values assigned on an arbitrary scale from 10 (least soft) to 100 (softest).

The handfeel values quoted in the Examples are measurements made on the surface of the sheet which was in contact with the surface of the second creping drum.

In the Examples, a dual creping method and apparatus of the type described in our British Patent Application No. 8401492 was used to produce the creped web.

EXAMPLE I

Example I illustrates the increased softness of light-weight two ply tissues produced by the invention where the smooth, soft sides of the creped webs can be turned out as compared to two-ply tissues produced on a conventional dry crepe Yankee machine.

A web is formed of 100% bleached sulfate pulp on a conventional fourdrinier machine having a Yankee dryer modified by the addition of a second creping cylinder to enable the practice of the dual creping process. The web is dried on the Yankee to 97% dryness (3% moisture) at the point of creping. Adhesion to the Yankee was augmented by the spraying of a conventional creping adhesive onto the Yankee surface. The web is then creped from the Yankee dryer with the speed of the Yankee 6% greater than the speed of the second creping drum, thus providing a web for the second creping step having 6% crepe.

The web was then pressed onto the second creping cylinder using a 35.6 cm. diameter Neoprene-covered roll having a "Teflon" outer sleeve - Teflon is a registered Trade Mark. In accordance with the invention, a thermoplastic creping adhesive was applied to the second creping cylinder as an aqueous dispersion containing 11.1% polymer solids using a spray configuration. The polymer material solids was a mixture of 90% high molecular weight (molecular weight = 750,000) polyvinyl acetate having a T_g of 32°C. and 10% low molecular weight (molecular weight = 75,000) copolymer of vinyl acetate and octyl maleate having a T_g of -43°C. The aqueous polymer dispersion was sprayed onto the creping cylinder surface at a rate sufficient to apply 0.2 gm of dry polymer solids per square metre of cylinder surface. The second creping cylinder was run at a speed of 13.2m/sec and heated with steam to obtain a sheet temperature at the creping blade of 132°C. The web was then creped from the cylinder using a creping blade set at the creping angle of 8° above the radial line passing through the point of contact of the blade and the cylinder. The creped web was then wound into a roll with a speed differential allowing 8% aditional crepe to be developed in the web. The web was then rewound into a two-ply product in which the web surfaces which contacted the second creping cylinder were turned out. The properties of the resulting two-ply product are given in the following Table:

BW	39.5 g/m2
Bulk	0.655 cm/24 sheets
MDT	264 g/cm
MDS	18%
CDT	97 g/cm
CDS	9.6%
HF	91

A two-ply product made on a conventional dry-crepe Yankee paper machine without the invention was not available using an identical pulp furnish. A product prepared using a similar furnish comprised of 70% softwood sulfate pulp and 30% hardwood sulfate pulp had the following physical properties:

BW	40.7 g/m2
Bulk	0.681 cm/24 sheets
MDT	172 g/cm
MDS	22%
CDT	59 g/cm
CDS	4.7%
HF	57

Handfeel (HF) is evaluated subjectively on an arbitrary scale in comparison with standard samples having predetermined HF values. The softest products, available commercially, are rated at about 100 using the scale employed for the above measurements, whereas conventional, two-ply dry crepe tissues typically are rated between 55 and 70. The handfeel rating of 91 for the product made using the invention is significantly softer than the two-ply products produced using conventional methods.

It is desirable to produce tissue products which are both soft and strong. Increased softness can usually be obtained by reducing the strength of a creped tissue product. A further significant advantage of this invention is that the greater softness, as shown in this Example, was attained with a substantially greater tensile strength.

EXAMPLE II

Example II illustrates the increased bulk and softness of a single-ply tissue product produced by the invention.

A web was formed on a conventional fourdrinier paper machine from a pulp mixture of 88% softwood bleached kraft and 12% secondary fiber. The wet web was pressed and dried on a Yankee cylinder to a dryness of 97% just prior to the creping blade. A conventional creping adhesive was applied to the Yankee cylinder surface in an amount of 0.25 g/kg of product to improve adhesion of the web to the Yankee surface. The web was creped from the Yankee surface under conditions allowing 6% crepe in the web prior to the second creping step. The web after Yankee creping had the following physical properties:

BW	25.3 g/m^2
Bulk	0.323 cm/24 sheets
MDT	169 g/cm
MDS	12.3%
CDT	58 g/cm
CDS	7.1%
MSS	9.3%

The dry web was then pressed onto a 1.52 metre diameter, steam-heated second creping cylinder. This cylinder was coated with a creping adhesive composition in the form of a polymer film which provides the adhesion between the web and the cylinder surface. The polymer film was sprayed onto the cylinder surface as an aqueous dispersion containing 9% polymer solids at the rate of 0.22 grams of dry polymer solids per square metre of cylinder surface. The polymer solids was a mixture of 70% of high molecular weight polyvinyl acetate (molecular weight = 1,200,000) having a T_g of 36°C. and 30% of low molecular weight polyvinyl acetate (molecular weight = 125,000) having a T_g of 32°C. The cylinder surface speed was 12.7 m/sec. After the web is pressed on the cylinder and polymer film, the web and film are heated by the cylinder to a temperature of 132°C. just prior to reaching the

creping blade. The creping blade is set such that the creping angle is 4^{o} above the cylinder radial line at the point of contact. The creped web issuing from the creping cylinder is wound into a roll at a speed of 11.4 m/sec resulting in a total of 18% crepe in the dual creped web. The physical properties of the resultant creped web are given in the following Table:

BW	28.7 g/m^2
Bulk	0.541 cm/24 sheets
MDT	106 g/cm
MDS	22.6%
CDT	48 g/cm
CDS	10.7%
HF	90

The product produced by this dual creping process employing the creping adhesive composition of this invention in the second creping step has a substantially greater softness (HF 90) compared to handfeel ratings of between 35 and 55 for single-ply dry creped tissue webs at the same tensile strength levels. The softness of single-ply dry creped webs are in the low to intermediate range of softness of tissue products, whereas the softness of the single-ply product of this invention approaches that of the highest softness products in the marketplace. In addition to the increased softness, the bulk of the dual creped product of this invention was increased by 68% over the bulk of the dry-creped web as removed from the Yankee dryer. Further, the cross-direction stretch of the dual creped web was also increased substantially.

These examples illustrate the superior softness attainable in webs produced by the practice of this invention. The softness effect is greatest in the surface of the web which contacted the second creping drum. Hence, the greatest product improvement is attained in the manufacture of two-ply tissue products in which the softer surface of each of the two plies is turned outward. In one-ply tissue webs, only one of the surfaces will have the superior softness.

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CLAIMS:

1. A thermoplastic creping adhesive composition which is in the form of an aqueous polymer dispersion, comprising, as solid adhesive components dispersed in an aqueous medium:

(a) a major proportion of a vinyl acetate homopolymer and/or a vinyl acetate copolymer in which the vinyl acetate units form at least 90% by weight of the polymer, the said homopolymer or copolymer having a molecular weight of from 500,000 to 1,500,000 and a glass transition temperature of from 28 to 36°C, and

(b) a minor proportion of a vinyl acetate homopolymer or copolymer having a molecular weight of from 5,000 to 250,000 and a glass transition temperature of from -50 to 32°C.

2. A creping adhesive composition according to Claim 1, wherein component (b) is a vinyl acetate homopolymer having a molecular weight of from 100,000 to 250,000.

3. A creping adhesive composition according to Claim 2, wherein the amount of component (b) is from 20 to 40% by weight, on a dry solids basis, based on the total weight of the solid adhesive components of the adhesive composition.

4. A creping adhesive composition according to Claim 1, wherein component (b) is a copolymer of vinyl acetate having a molecular weight of from 5,000 to 75,000.

5. A creping adhesive composition according to Claim 4, wherein the amount of component (b) is from 4 to 10% by weight, on a dry solids basis, based on the total weight of the solid adhesive components of the adhesive composition.

6. A creping adhesive composition according to any one of the preceding claims, wherein component (b) is a copolymer of vinyl acetate and a monomer selected from octyl maleate, butyl acrylate and 2-ethyl hexyl acrylate.

7. A thermoplastic creping adhesive composition substantially as hereinbefore described in Example I or Example II.